Aramid Rope Testing-

Slow pull and drop testing of 9.5mm Sterling Tactical Response

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Rope rescue response organizations have traditionally utilized life safety lines constructed out of synthetic fibers such as Nylon and Polyester. Additionally, the lines are commonly manufactured using a kernmantle design that includes a load bearing core, protected by an outer sheath. Mountain rescue teams have typically favored 11mm diameter lines, whereas fire rescue and industrial rope rescue teams have commonly utilized 12.5mm diameter lines. However, as risk management perspectives have evolved so too have equipment choices utilized in rope rescue response. For example, it is an increasingly common approach for some mountain rescue teams to conduct their backcountry rope rescues with 9.5mm life safety lines as opposed to 11mm. The lighter weight and better compatibility with certain devices/systems is often cited as reasoning for utilizing a thinner life safety line. Many fire rescue teams have followed a similar approach by dropping diameter down to 11mm from 12.5mm.

Language and terminology appear to play a role in some of these risk management choices and equipment cache strategies. In the 2012 edition of NFPA 1983 the standard changed nomenclature such that Light Use (L) rope was now classified as Technical Use (T). Prior to the change in nomenclature, it seemed folly to support live loads in high consequence terrain with a “light use” rope, but change the name to “technical” and it is now a reasonable approach, despite no change in the rope or its performance characteristics. Current NFPA 1983 (under NFPA 2500) has updated parameters such that many 11mm ropes meet the General Use (G) performance criteria. These are trends to be applauded and reflect not only innovations in rope manufacturing methods, but also proactive and open-minded approaches to standard writing. Loui McCurley of PMI wrote an excellent piece online addressing some of these industry evolutions as well as important considerations for adopting change in equipment cache management (https://pmirope.com/nfpa-11mm-g-rope-is-it-a-gimmick/).

Rigging for Rescue’s interest in conducting testing on the Sterling Tactical Response (STR) rope was largely piqued by discussions and questions from our rope rescue educational/training clientele. These customers were either using STR or entertaining its adoption for their own rope rescue operations. At ITRS 2019, we presented findings from drop testing and slow pull testing on 9.5mm rope, but the data set was limited to Nylon and/or Polyester lines. And while we have conducted a small amount of research on other 9-9.5mm lines constructed with aramid fibers (e.g. Sterling OpLux, Bluewater Canyonline), the testing we conducted in 2024 on STR was our first test series of a rope that included aramid fibers that could be considered more than just a 'quick look' examination.

Aramids are a class of strong synthetic fibers with high heat-resistant properties used in tires, marine lines, and aerospace as well as military applications, just to name a few. Examples include Kevlar, Twaron, Nomex, and Technora.

In assessing capabilities versus limitations, beneficial qualities of aramid fibers include:

- High heat resistance
- High tensile strength
- Excellent abrasion resistance
- Low elongation

Limitations include:

- Prone to flex fatigue
- UV prone
- Cost

There are a number of rope rescue organizations as well as recreational ropework practitioners that are utilizing life lines constructed with Technora or other aramid fibers. Firefighter escape line, for example, uses aramid fiber for the purpose of optimizing the quality of high heat resistance. Whereas recreational canyoning practitioners may favor lines constructed with an aramid sheath to optimize abrasion resistance while keeping the core as a generic synthetic fiber like Nylon. And standby rescue organizations such as wildland fire REMS teams, have reported to us that they use ropes like STR to strike a balance of qualities like abrasion and heat resistance in combination with the performance qualities of long shelf-life and increased elongation of a Nylon core.

There are other 9.5mm ropes from different manufacturers that are similarly constructed as STR. We chose to limit our 2024 test series to only the STR largely because of time and cost. STR is a kernmantle constructed rope made with a Nylon core and a Technora sheath. It is a EN 1891: Type B rope in 9.5mm diameter and has a rated MBS of 30kN.

The tests we conducted transpired over multiple testing sessions during calendar year 2024. Test methods included:

- Drop testing
- Slow pull testing

All of the drop tests were conducted to the Belay Competence Drop Test Method (BCDTM). Numerous references to this drop test method, parameters, and performance criteria have been previously documented at ITRS and will not be repeated in this paper. All slow pull testing was conducted with a hydraulic ram tensile-testing device. Force measurements were recorded with a Linegrip brand Linescale 3 device. Sampling rate was 1280 Hz for the drop tests and 640 Hz for the slow pull tests. In total, 102 tests were conducted over the course of the research project.

Devices examined included:

- Bluewater VT Prusik 8mm
- Petzl Maestro S
- CMC 11mm Clutch
- Petzl Mini Traxion

The research project testing sequence of events generally followed a chronology of:

1. BCDTM drop tests on some of the aforementioned devices with STR as the host rope
2. Slow pull tests of the components from the drop tests (i.e. the rope segment of STR and the VT Prusik from that same drop test, independently pulled to failure)
3. Slow pull tests of brand new, never used STR (to compare to the samples from the drop tests)
4. Slow pull slips tests of STR through VT Prusiks as 7/1 and 6/1 Schwabisch hitches (aka Max/1 hitch)
5. Slow pull slip tests of STR through anchored mechanical descent control devices (DCD) - Petzl Maestro and CMC Clutch
6. And slow pull tests of STR and Sterling HTP 9.5mm through an anchored Petzl Mini Traxion mechanical toothed progress-capture device.

I. Bluewater VT Testing

i. <u>BCDTM tests with 8mm Bluewater VT 7/1 as fall arrest device</u>

A total of 20 tests were conducted. All rope was brand new, never used 9.5mm STR. All Bluewater VT Prusiks were brand new, never used. Prusik hitches were securely dressed and stressed by the test rigger (i.e. optimized for fall arrest performance). All 20 tests successfully passed the BCDTM performance criteria. The overall range of both fall arrest system (FAS) extension and maximum arrest force (MAF) was small.

Host Rope	Belay Device	# of tests	FAS (cm)	MAF (kN)
STR 9.5mm	VT 7/1	20	343 - 364	11.14 - 13.4

ii. BCDTM tests with 8mm Bluewater VT 6/1 as fall arrest device

A total of only two tests were conducted. The VT Prusik hitch had a nominal length that allowed for a seventh turn on the standing end of the rope to produce a 7/1 or Max/1 Schwabisch Hitch. We elected to remove one turn in order to conduct a quick look examination of a sub-optimal hitch configuration. All other parameters remained the same, with the exception of test #D-020824-22 (see Appendix). On test #D-020824-22 the test rigger intentionally loosened the 6/1 hitch prior to the drop test. The hitch was dressed neatly, just not stressed and snug on the rope. The purpose of this was to experiment with some rigging set-ups that deviated from optimal conditions. Both 6/1 tests passed the BCDTM performance criteria. The tests had reduced MAF and increased FAS extension compared to the 7/1 data set.

Host Rope	Belay Device	# of tests	FAS (cm)	MAF (kN)
STR 9.5mm	VT 6/1	2	360 - 377	11.27 - 11.71

iii. Slow pull tensile tests of drop-tested STR rope segments

A total of 10 tests were conducted. The STR rope segments were randomly selected from the overall pool of 22 drop-test samples from the VT 7/1 and VT 6/1 BCDTM tests. The intent was to examine the knotted breaking strength of the rope segment that was subjected to the fall arrest of a BCDTM drop test. And then assess for evidence of tensile strength degradation. Tests were conducted with bowline ties at each end and were pulled to failure.

Rope	# of tests	Min (kN)	Max (kN)	Mean (kN)	Other
STR 9.5mm (drop-tested)	10	17.67	20.28	18.67	Mean=62% of MBS (30 kN)

iv. Slow pull tensile tests of drop-tested VT devices

A total of 10 tests were conducted. The VT samples were from the same randomly selected STR rope segments (above; section iii) from the overall pool of 22 drop-test samples from the VT 7/1 and VT 6/1 BCDTM tests. The intent was to examine the breaking strength of the VT that was subjected to the fall arrest of a BCDTM drop test. And then assess for evidence of tensile strength degradation based on a comparison to manufacturer MBS. Tests were conducted end-to-end and were pulled to failure.

Device	# of tests	Min (kN)	Max (kN)	Mean (kN)
VT Prusik (drop-tested)	9	17.29	21.70	19.93

Note: Minimum Breaking Strength (MBS) for a brand new 8mm VT Prusik is rated at 20kN.

v. Slow pull tensile tests of brand new, never used STR rope

A total of 10 tests were conducted. The STR rope segments were brand new, never used. The intent was to examine the knotted breaking strength of the rope segment to create a baseline for comparison. And then assess that baseline against the drop-tested STR segments (above; section iii). Tests were conducted with bowline ties at each end and were pulled to failure.

Rope	# of tests	Min (kN)	Max (kN)	Mean (kN)	Other
STR 9.5mm (new)	10	17.08	19.94	18.87	Mean=63% of MBS (30kN)

vi. Slow pull slip tests with Bluewater VT 7/1 as rope grab

A total of 10 tests were conducted. All STR rope and VT Prusiks were brand new, never used. All VT Prusiks were dressed and stressed for optimal gripping performance. Tests were stopped after the initial slip of the VT.

Host Rope	# of tests	Hitch Configuration	Initial slip (kN)
STR 9.5mm	10	VT 7/1	12.85 - 15.78

vii. Slow pull slip tests with Bluewater VT 6/1 as rope grab

A total of 10 tests were conducted. All STR rope and VT Prusiks were brand new, never used. All VT Prusiks were dressed and stressed for optimal gripping performance. Tests were stopped after the initial slip of the VT.

Host Rope	# of tests	Hitch Configuration	Initial slip (kN)	Other
STR 9.5 mm	10	VT 6/1	8.87 – 11.69	One test required manual tightening of hitch to initiate grab

On test SP-080224-03, it took three separate attempts by the test rigger to achieve adequate dressing/stressing for the VT 6/1 sample to successfully grab the host rope during the slow pull. The first two attempts failed to grab the host rope when the test was initiated.

II. Mechanical DCD Testing

Rope rescue devices such as the Petzl Maestro and CMC Clutch are manufactured to certain specifications such that they meet various third-party standards from organizations such as NFPA, EN, UL, and ANSI. Depending on the device, it may include features and performance qualities that certify it as a pulley, a DCD, and a belay device all per specific published standards criteria. And a specific range of acceptable rope diameter to be reeved through the device for the test parameters of the standard in question is also conspicuously noted. Generally, for the standards applicable to both the CMC 11mm Clutch (Gray) and Petzl Maestro S, the rope diameter range is 10.5-11.5mm. Both manufacturers also offer models for the larger 12.5mm rope diameter. Our testing only evaluated the devices designed for 11mm rope.

Aside from the third-party stamps associated with a device, manufacturers also publish a rope diameter compatibility range for their devices. The Petzl Maestro S is compatible with 10-5-11.5mm rope. The CMC 11mm Clutch is compatible with 10.5-11mm rope.

So why test devices manufactured, certified, and rated to a specific rope diameter with an incompatible rope like 9.5mm STR? Because ropework practitioners are a curious lot and some will elect to experiment with incompatible rope and device combinations. And we were curious ourselves to see what the capabilities and limitations were of the two devices with an incompatible smaller diameter rope.

Our testing of the Clutch and Maestro - in combination with the 9.5mm STR - began with slow pull slip tests. The STR was reeved through each device and the devices were anchored to the tensile testing machine. The standing end of the STR was then tied to the hydraulic ram. The test was stopped when an initial slip occurred through the device.

i. <u>Slow pull slip tests with CMC Clutch as rope grab</u>

A total of 10 tests were conducted. All STR rope segments were brand new, never used. The CMC Clutch had been previously used in other testing projects. The Clutch handle was rotated to Stop mode for each test.

Host Rope	# of tests	Device	Initial slip (kN)	Other
STR 9.5mm	10	CMC Clutch	1.32 – 1.59	Device in Stop mode

ii. Slow pull slip tests with Petzl Maestro as rope grab

A total of 10 tests were conducted. All STR rope segments were brand new, never used. The Petzl Maestro had been previously used in other testing projects. By design, the Maestro device defaults to a locked position via a spring-actuated camming effect, so no other device manipulation was required to secure the line.

Host Rope	# of tests	Device	Initial slip (kN)
STR 9.5mm	10	Petzl Maestro S	5.79 – 6.24

Because the Clutch with 9.5mm STR indicated poor device/rope compatibility, we elected not to examine that combination with BCDTM drop tests. Conversely, the Maestro indicated favorable compatibility as a rope grab on 9.5mm STR and so we did pursue additional examinations of that combination via BCDTM drop tests.

iii. BCDTM tests with Petzl Maestro as fall arrest device

A total of 10 tests were conducted. All STR rope segments were brand new, never used. The Petzl Maestro had been previously used in other testing projects. All of the drop tests failed to pass the BCDTM criteria due to excessive FAS extension (i.e. >100cm over the initial 300cm rope-in-service). The 200kg test mass was successfully arrested on all 10 tests and with passing MAF values (i.e. <15kN). There was no evidence of visible damage on any of the rope segments.

Host Rope	Belay Device	# of tests	FAS (cm)	MAF (kN)	Other
STR 9.5mm	Petzl Maestro S	7	401 – 421	4.27 – 6.54	Failed due to > 400 cm FAS extension

III. Mechanical toothed progress-capture testing (slow pull)

Only three tests were conducted on one make/model of toothed progress-capture device – the Petzl Mini Traxion. Much of the previous slow pull testing we have conducted with toothed progress-capture devices on 9.5-11mm rope result in a ruptured sheath at around 5-7kN depending on make, model, and diameter. We were curious as to whether or not there was any substantive difference between STR 9.5mm and a similar diameter rope without the Technora sheath (specifically, 9.5mm Sterling HTP). All rope was brand new, never used. And the Mini Traxions were also brand new, never used. In three tests we managed to irreparably damage both Mini Traxion devices and the sheath was ruptured on all of the rope samples tested.

Host Rope	Device	# of tests	Force (kN)	Result
STR 9.5mm; HTP 9.5mm	Petzl Mini Traxion	3	6.92 – 7.66	• Ruptured sheath on all samples • Devices irreparably damaged

Summary of Findings and Recommendations

The Bluewater VT as a 7/1 Schwabisch Hitch (aka Max/1) with STR 9.5mm as the host rope passed the BCDTM criteria on every test conducted. The results also indicated a tight range for both MAF and FAS extension. And the breaking strength of the component parts from the drop-testing appeared to be unaffected (i.e. minimal degradation relative to MBS). However, the sample size is small - N=20.

Our 2024 test series on STR 9.5mm is just the most recent in our examinations of 9.5-10mm host ropes to the BCDTM standard. In 2019, we conducted 36 BCDTM drop tests on 9.5-10mm Nylon, Polyester, and Nylon/Polyester ropes with the fall arrest device as a VT 7/1 or VT 6/1 friction hitch. The research findings were presented at ITRS 2019. All 36 drop tests passed the BCDTM criteria. The STR 9.5mm with a VT 7/1 as the fall arrest device is just the latest rope and device combination of 9.5mm to pass the BCDTM, per the testing we have conducted to date.

The mechanical DCDs we examined with the STR 9.5mm were not designed for that rope diameter and are specifically indicated as incompatible per the manufacturers published owner's manuals. The testing we conducted was merely experimental in nature to be better able to understand the capabilities and limitations of the two DCDs examined. We recommend following the manufacturers guidelines for rope compatibility with the two respective devices – Petzl Maestro S and CMC 11mm Clutch.

If your rope rescue team is seeking a rope platform for lighter weight approaches to mountain rescue (or other rope disciplines involving longer ingress/egress), we recommend considering 9.5mm as an alternative to 11mm. There are numerous examples of teams currently using 9.5mm as their rope rescue life line in backcountry operations. The list of capabilities and limitations is lengthy and should be carefully considered prior to adoption. For example, longer embankment rescue scenarios (i.e. >60m) tend to produce a 'bungee' like effect for the litter attendants when suspended by 9.5mm rope – even in dual tension applications. The rope has greater elongation than 11mm for a given applied force. Abrasion resistance over unprotected edges is an important consideration. The risk management decision-making calculus runs the gamut depending on your mission profile of people, equipment, and environment.

Furthermore, if your mountain rescue team ascribes high value to the additional abrasion resistance of an aramid-sheathed rope, then the STR 9.5mm may be a suitable option, per the testing we conducted. However, with a N value of 20 – combined with brand new, never used components – this is a small sample size for generating decision-making. Previous 'quick look' testing we have conducted on used 9-10mm aramid-sheathed ropes have produced anomalous results, which contribute to our preference for a Nylon and/or Polyester life line. Your risk management and purchasing decision may only be delivering a marginal benefit in specific circumstances (i.e. abrasion resistance). There may very well be more to the story.

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Appendix A: Drop Testing & Slow Pull Testing Summary Tables

Legend

MAF	Maximum Arrest Force
RIS	Rope in Service
MNT	Measurement not Taken
FAS	Fall Arrest System
STR	Sterling Tactical Response
BW	Bluewater
HTP	High Tenacity Polyester
MBS	Minimum Breaking Strength

Bluewater VT Testing

i. BCDTM tests with 8mm Bluewater VT 7/1 as fall arrest device

STR 9.5mm BCDTM Drop Tests - 7/1 VT Prusik

Test #	Host rope	Device	Hitch	Test Mass (kg)	RIS (cm)	Freefall Distance (cm)	MAF (kN)	FAS Ext (cm)	Slide (cm)
D-020824-01	STR 9.5mm	BW VT 8mm	7/1	200	300	100	12.91	344	12
D-020824-02	STR 9.5mm	BW VT 8mm	7/1	200	300	100	11.99	354	22
D-020824-03	STR 9.5mm	BW VT 8mm	7/1	200	300	100	13.21	348	12
D-020824-04	STR 9.5mm	BW VT 8mm	7/1	200	300	100	12.09	354	23
D-020824-05	STR 9.5mm	BW VT 8mm	7/1	200	300	100	11.14	352	23
D-020824-06	STR 9.5mm	BW VT 8mm	7/1	200	300	100	12.56	356	25
D-020824-07	STR 9.5mm	BW VT 8mm	7/1	200	300	100	12.79	359	26
D-020824-08	STR 9.5mm	BW VT 8mm	7/1	200	300	100	11.58	353	23

D-020824-09	STR 9.5mm	BW VT 8mm	7/1	200	300	100	12.58	359	26
D-020824-10	STR 9.5mm	BW VT 8mm	7/1	200	300	100	13.4	343	11
D-020824-11	STR 9.5mm	BW VT 8mm	7/1	200	300	100	12.72	356	23
D-020824-12	STR 9.5mm	BW VT 8mm	7/1	200	300	100	12.92	353	24
D-020824-13	STR 9.5mm	BW VT 8mm	7/1	200	300	100	13.09	350	13
D-020824-14	STR 9.5mm	BW VT 8mm	7/1	200	300	100	12.49	362	25
D-020824-15	STR 9.5mm	BW VT 8mm	7/1	200	300	100	12.68	354	26
D-020824-16	STR 9.5mm	BW VT 8mm	7/1	200	300	100	12.74	358	24
D-020824-17	STR 9.5mm	BW VT 8mm	7/1	200	300	100	12.62	361	25
D-020824-18	STR 9.5mm	BW VT 8mm	7/1	200	300	100	11.33	355	23
D-020824-19	STR 9.5mm	BW VT 8mm	7/1	200	300	100	13.63	353	13
D-020824-20	STR 9.5mm	BW VT 8mm	7/1	200	300	100	12.13	364	28

ii. BCDTM tests with 8mm Bluewater VT 6/1 as fall arrest device

STR 9.5mm BCDTM Drop Tests - 6/1 VT Prusik									
Test #	Host rope	Device	Hitch	Test Mass (kg)	RIS (cm)	Freefall Distance (cm)	MAF (kN)	FAS Ext (cm)	Slide (cm)
D-020824-21	STR 9.5mm	BW VT 8mm	6/1	200	300	100	11.71	360	24
D-020824-22	STR 9.5mm	BW VT 8mm	6/1	200	300	100	11.27	377	41

iii. Slow pull tensile tests of drop-tested STR rope segments

STR 9.5mm (drop-tested) Slow Pull Tests - Bowline vs. Bowline				
Test #	**Sample***	**Test Configuration**	**Sampling Rate (hz)**	**Breaking Strength (kN)**
SP-020924-11	STR:D-020824-07	Bowline vs. bowline	640	17.67
SP-020924-14	STR:D-020824-17	Bowline vs. bowline	640	18.61
SP-020924-15	STR:D-020824-11	Bowline vs. bowline	640	20.28
SP-020924-18	STR:D-020824-14	Bowline vs. bowline	640	18.83
SP-020924-19	STR:D-020824-08	Bowline vs. bowline	640	18.38
SP-072424-06	STR:D-020824-13	Bowline vs. bowline	640	17.92
SP-072424-07	STR:D-020824-21	Bowline vs. bowline	640	18.84
SP-072424-08	STR:D-020824-04	Bowline vs. bowline	640	17.79
SP-072424-09	STR:D-020824-10	Bowline vs. bowline	640	19.53
SP-072424-10	STR:D-020824-06	Bowline vs. bowline	640	18.86

*Note: The alpha-numeric Sample identifier indicates the STR sample from that specific BCDTM drop test

iv. Slow pull tensile tests of drop-tested VT devices

BW VT Prusik 8mm (drop-tested) Slow Pull Tests: End to End					
Test #	**Sample***	**Device**	**Test Configuration**	**Sampling Rate (hz)**	**Breaking Strength (kN)**
SP-072424-01	VT from D-020824-21	BW VT 8mm	End to end	640	16.77*
SP-072424-02	VT from D-020824-10	BW VT 8mm	End to end	640	20.34
SP-072424-03	VT from D-020824-06	BW VT 8mm	End to end	640	19.87
SP-072424-04	VT from D-020824-04	BW VT 8mm	End to end	640	20.86
SP-072424-05	VT from D-020824-13	BW VT 8mm	End to end	640	20.22
SP-020924-12	VT from D-020824-07	BW VT 8mm	End to end	640	19.57
SP-020924-13	VT from D-020824-17	BW VT 8mm	End to end	640	17.29
SP-020924-16	VT from D-020824-11	BW VT 8mm	End to end	640	21.70
SP-020924-17	VT from D-020824-14	BW VT 8mm	End to end	640	18.85
SP-020924-20	VT from D-020824-08	BW VT 8mm	End to end	640	20.72

* Note: The alpha-numeric Sample identifier indicates the VT sample from that specific BCDTM drop test
** Note: This test was from a VT 6/1 drop-test sample. The other 9 tests were all VT 7/1 drop test samples

v. Slow pull tensile tests of brand new, never used STR rope

STR 9.5mm (New) Slow Pull Tests - Bowline vs. Bowline				
Test #	**Host Rope**	**Test Configuration**	**Sampling Rate (hz)**	**Breaking Strength (kN)**
SP-072524-01	STR 9.5mm	Bowline vs. bowline	640	19.30
SP-072524-02	STR 9.5mm	Bowline vs. bowline	640	17.08
SP-072524-03	STR 9.5mm	Bowline vs. bowline	640	19.94
SP-072524-04	STR 9.5mm	Bowline vs. bowline	640	19.09
SP-072524-05	STR 9.5mm	Bowline vs. bowline	640	19.56
SP-072524-06	STR 9.5mm	Bowline vs. bowline	640	18.73
SP-072524-07	STR 9.5mm	Bowline vs. bowline	640	18.59
SP-072524-08	STR 9.5mm	Bowline vs. bowline	640	18.85
SP-072425-09	STR 9.5mm	Bowline vs. bowline	640	18.99
SP-072524-10	STR 9.5mm	Bowline vs. bowline	640	18.59

vi. Slow pull slip tests with Bluewater VT 7/1 as rope grab

STR 9.5mm (new) slip tests - VT Prusik 7/1 (new)

Test #	Host Rope	Device	Test Configuration	Sampling Rate (hz)	MAF (kN)
SP-020924-01	STR 9.5mm	BW VT 8mm	7 over 1 slip test	640	14.02
SP-020924-02	STR 9.5mm	BW VT 8mm	7 over 1 slip test	640	15.08
SP-020924-03	STR 9.5mm	BW VT 8mm	7 over 1 slip test	640	15.07
SP-020924-04	STR 9.5mm	BW VT 8mm	7 over 1 slip test	640	15.78
SP-020924-05	STR 9.5mm	BW VT 8mm	7 over 1 slip test	640	11.61
SP-072524-11	STR 9.5mm	BW VT 8mm	7 over 1 slip test	640	15.13
SP-072524-12	STR 9.5mm	BW VT 8mm	7 over 1 slip test	640	14.27
SP-072524-13	STR 9.5mm	BW VT 8mm	7 over 1 slip test	640	13.00
SP-072524-14	STR 9.5mm	BW VT 8mm	7 over 1 slip test	640	12.85
SP-072524-15	STR 9.5mm	BW VT 8mm	7 over 1 slip test	640	15.44

vii. Slow pull slip tests with Bluewater VT 6/1 as rope grab

STR 9.5mm (new) slip tests - VT Prusik 6/1 (new)

Test #	Host Rope	Device	Test Configuration	Sampling Rate (hz)	MAF (kN)
SP-020924-06	STR 9.5mm	BW VT 8mm	6 over 1 slip test	640	11.69
SP-020924-07	STR 9.5mm	BW VT 8mm	6 over 1 slip test	640	10.68
SP-020924-08	STR 9.5mm	BW VT 8mm	6 over 1 slip test	640	11.19
SP-020924-09	STR 9.5mm	BW VT 8mm	6 over 1 slip test	640	11.63
SP-020924-10	STR 9.5mm	BW VT 8mm	6 over 1 slip test	640	MNT
SP-080124-01	STR 9.5mm	BW VT 8mm	6 over 1 slip test	640	8.87
SP-080124-02	STR 9.5mm	BW VT 8mm	6 over 1 slip test	640	9.60
SP-080224-03	STR 9.5mm	BW VT 8mm	6 over 1 slip test	640	0*
SP-080124-03B	STR 9.5mm	BW VT 8mm	6 over 1 slip test	640	10.14
SP-080124-04	STR 9.5mm	BW VT 8mm	6 over 1 slip test	640	9.42
SP-080124-05	STR 9.5mm	BW VT 8mm	6 over 1 slip test	640	10.14

*Note: This test took three attempts to get the VT 6/1 to successfully grab the host rope during the slow pull test. We finally achieved a successful grab of the Prusik and that data point is recorded as SP-080124-03B

Mechanical DCD Testing

i. Slow pull slip tests with CMC Clutch as rope grab

STR 9.5mm (new) Slow Pull Slip Tests - CMC 11m Clutch

Test #	Host Rope	Device	Test Configuration	Sampling Rate (hz)	RIS (cm)	Slip Force (kN)
SP-072424-21	STR 9.5 mm	CMC 11mm Clutch	Device vs knotted end	640	43	1.50
SP-072424-22	STR 9.5 mm	CMC 11mm Clutch	Device vs knotted end	640	43	1.43
SP-072424-23	STR 9.5 mm	CMC 11mm Clutch	Device vs knotted end	640	43	1.59
SP-072424-24	STR 9.5 mm	CMC 11mm Clutch	Device vs knotted end	640	43	1.37
SP-072424-25	STR 9.5 mm	CMC 11mm Clutch	Device vs knotted end	640	43	1.32
SP-072424-26	STR 9.5 mm	CMC 11mm Clutch	Device vs knotted end	640	43	1.38
SP-072424-27	STR 9.5 mm	CMC 11mm Clutch	Device vs knotted end	640	43	1.35
SP-072424-28	STR 9.5 mm	CMC 11mm Clutch	Device vs knotted end	640	43	1.41
SP-072424-29	STR 9.5 mm	CMC 11mm Clutch	Device vs knotted end	640	43	1.35
SP-072424-30	STR 9.5 mm	CMC 11mm Clutch	Device vs knotted end	640	43	1.39

ii. Slow pull slip tests with Petzl Maestro as rope grab

STR 9.5mm Slip Tests - Petzl Maestro S

Test #	Host Rope	Device	Test Configuration	Sampling Rate (hz)	RIS (cm)	Slip Force (kN)
SP-072424-11	STR 9.5 mm	Petzl Maestro S	Device vs knotted end	640	43	5.79
SP-072424-12	STR 9.5 mm	Petzl Maestro S	Device vs knotted end	640	43	6.15
SP-072424-13	STR 9.5 mm	Petzl Maestro S	Device vs knotted end	640	43	5.96
SP-072424-14	STR 9.5 mm	Petzl Maestro S	Device vs knotted end	640	43	5.83
SP-072424-15	STR 9.5 mm	Petzl Maestro S	Device vs knotted end	640	43	5.91
SP-072424-16	STR 9.5 mm	Petzl Maestro S	Device vs knotted end	640	43	6.24
SP-072424-17	STR 9.5 mm	Petzl Maestro S	Device vs knotted end	640	43	5.84
SP-072424-18	STR 9.5 mm	Petzl Maestro S	Device vs knotted end	640	43	5.88
SP-072424-19	STR 9.5 mm	Petzl Maestro S	Device vs knotted end	640	43	5.96
SP-072424-20	STR 9.5 mm	Petzl Maestro S	Device vs knotted end	640	43	6.12

iii. BCDTM tests with Petzl Maestro as fall arrest device

STR 9.5mm (new) BCDTM Drop Tests - Petzl Maestro S

Test #	Host rope & Diameter	Device	Test Mass (kg)	RIS (cm)	Freefall Distance (cm)	MAF (kN)	FAS Extension (cm)
DT-080124-01	STR 9.5mm	Petzl Maestro S	200	300	100	6.54	411.5
DT-080124-02	STR 9.5mm	Petzl Maestro S	200	300	100	4.47	401
DT-080124-03	STR 9.5mm	Petzl Maestro S	200	300	100	MNT	NA (device rigged backwards. Error)
DT-080124-03B	STR 9.5mm	Petzl Maestro S	200	300	100	4.63	402.5
DT-080124-04	STR 9.5mm	Petzl Maestro S	200	300	100	4.41	418
DT-080124-05	STR 9.5mm	Petzl Maestro S	200	300	100	4.28	421
DT-080124-06	STR 9.5mm	Petzl Maestro S	200	300	100	4.37	413.5
DT-080214-07	STR 9.5mm	Petzl Maestro S	200	300	100	4.27	414.5

Mechanical Toothed Progress-Capture testing (slow pull)

Test #	Host Rope	Device*	Test Configuration	Sampling Rate (hz)	Force (kN)	Results/Comments
SP-100224-06	STR 9.5mm/ HTP 3/8"	Petzl Mini Traxion	Device/STR vs Device/HTP	640 hz	7.66	Ruptured sheath on both ropes
SP-100224-07	STR 9.5mm	Petzl Mini Traxion	Device vs knotted end	640 hz	7.02	Ruptured sheath
SP-100224-08	HTP 3/8"	Petzl Mini Traxion	Device vs knotted end	640 hz	6.92	Ruptured sheath

*Note: Both of the Petzl Mini Traxion devices used in the tests were irreparably damaged